

CHAOTIC ARMS CONTROL:
DECISION MAKING FOR THE POST-COLD WAR

A Research Paper

Presented To

The Directorate of Research

Air Command and Staff College

In Partial Fulfillment of the Graduation Requirements of ACSC

by

Maj Dean Longo
Wg Cmdr Mohammad Alamgir
Lt Col Jeon

19971119 069

DTIC QUALITY INSPECTED 3

April 1996

4c

Disclaimer

The views expressed in this academic research paper are those of the authors and do not reflect the official position of the U.S. Government or the Department of Defense.

Contents

| | <i>Page</i> |
|--|-------------|
| DISCLAIMER..... | ii |
| LIST OF ILLUSTRATIONS..... | iv |
| ACKNOWLEDGEMENTS | v |
| ABSTRACT | vi |
| INTRODUCTION..... | 1 |
| Thesis..... | 3 |
| Methodology..... | 3 |
| RECENT US ARMS SALES POLICIES—THE DECISION MAKER’S DILEMMA | 6 |
| THE DECISION MAKING PROBLEM | 13 |
| Chaos Theory as an Answer | 15 |
| Applied Chaos Theory..... | 16 |
| Linear | 16 |
| Chaotic..... | 17 |
| Chaos Applied to Arms Control..... | 23 |
| Arms Control is Chaotic | 23 |
| Developing the Arms Control Attractor | 25 |
| CONCLUSION | 40 |
| Recommendations | 42 |
| Limitations of the Study | 43 |
| BIBLIOGRAPHY | 45 |

Illustrations

| | <i>Page</i> |
|--|-------------|
| Figure 1. Generic Decision Making Attractor | 20 |
| Figure 2. Instability | 21 |
| Figure 3. Generic Arms Control Attractor | 27 |
| Figure 4. Potential T-37 Sale to Great Britain Attractor | 28 |
| Figure 5. Potential Sale of F-117 to South Korea/India | 28 |

Acknowledgements

The authors would like to thank our Faculty Research Advisor, Major Robert Lyles for his guidance and support. We also wish to thank Majors Bruce DeBlois and Glenn James for their insights on Chaos Theory and patience as we tried to make sense out of it all; Dr. Abby Gray, for always taking the time to listen; Major Gil Castillo, AF/XOXI for getting us going in the right direction; and Col Frank Goldstein for his understanding. Finally, I thank my wife, Gayliene and daughter Megan, for their love, support, and attention.

Abstract

During the height of the cold war, arms sales reflected the bipolar competition between the United States and the Soviet Union. They were political in nature and designed to allow proxies to fight the battles of the superpowers. When the cold war ended, the established framework to justify arms sales disappeared while the level of weapons sales continued to climb. The apparently uncontrolled proliferation is coming under intense scrutiny. What is the proper balance between conventional arms control and arms sales in the post-cold war? What is the role, if any, of arms control agreements and negotiations?

We looked at the historical record and found no connection between arms sales and the onset of war over the past 200 years. Except for the introduction of the breech-loading rifled musket, there is also no data to suggest the sale of advanced weapons increases the intensity of war. The lack of connection between arms sales and war does not mitigate the problem many US Presidents are facing—US sold weapons are still used in conflicts around the world. The future of arms control focuses on minimizing these adverse effects of arms sales.

In order to minimize the adverse effects, we looked at Chaos Theory for possible answers. We built upon earlier studies to show decision making is the root of Chaotic results in human systems. We identified the attractors, stability, and controls necessary to reduce adverse effects of US arms sales.

Chapter 1

Introduction

*Military aid, like war, is a continuation of foreign policy by other means.*¹

Arms control in the modern era originated in post-World War II Europe. The Marshall Plan, designed to build a strong, self-reliant, and democratic Europe, free from Stalinist aggression, invested \$17 billion over four years in the security and economy of Europe.² Once overall security was established, the economically and militarily destroyed countries of Europe could rebuild their infrastructure and concentrate on essential needs.³

After the Marshall Plan, US arms sales stabilized at the \$500 million mark and saw modest growth during the latter part of the 1960s, before growing exponentially over the past twenty-five years.⁴ This growth ignited a controversy over increased weapons proliferation. Currently, there are approximately 233 arms-control oriented international organizations registered in the International Peace Directory; from the 356-member, Mauritius' based *Women's International League for Peace and Freedom* to the 100,000-plus member *Union of Concerned Scientists*.⁵ Each organization focuses attention on the presumably uncontrolled qualitative and quantitative proliferation of conventional weapons—the perceived cause of an increase in global conflict, especially within the third world.

But is the proliferation uncontrolled? Is it the cause of the increased conflict? Analyzing the rate and intensity of wars from 1800 until present does not support the conclusion that arms sales effect war. Quantitatively, the number of wars decreased to the lowest levels since 1800,⁶ yet arms sales increased from a negligible amount in 1800, to \$220 million in 1950, to \$33 billion in 1993.⁷

Qualitatively, analysis of the data reflects the same results. Except for the introduction of the breech-loading rifled musket in the 1850s,⁸ technological advances in weaponry have not significantly increased wartime casualty rates. Immediately after its introduction, wartime casualty rates jumped an order of magnitude and remained essentially at the levels we see today.⁹ “No other change—not even the aircraft or the tank, not even tactical nuclear weapons (at least not yet)—has affected warfare so quickly or fundamentally.”¹⁰ Data on the rate and intensity of war from 1800 until today backs up this claim. Lewis Richardson, in his study on the intensity of warfare, analyzed 315 conflicts with one thousand casualties or more. He classified seven logarithmic-based “magnitudes” of war from “0” with only 1 casualty to “7” with 10 million or greater casualties. His results showed a jump in lethality after 1850, and a stabilization of lethality afterward. No wars initiated between 1800-1850 reached a magnitude “6”; however, from 1851-1900, 43 percent of all magnitude “6” wars occurred, and 1900-1950, all the magnitude “7” wars began.¹¹

In every study, the results also show a stabilized rate of war after the onset of conventional arms proliferation. Only 15 percent of the wars in the past two hundred years and 35 percent of the wars this century occurred from 1950 to today. Of those, only

eight of the top 50 worst years for war (years experiencing the most number of nations fighting) occurred after 1950.¹²

Simply concluding arms sales do not alter the level of conflict *does not mitigate the problem that conflicts do involve US weapons*. To minimize these problems, we will look at the arms control policies of selected US Presidents during the era of exponential arms sales growth (1950-present). We will identify some incongruencies between the goals and results, and propose an underlying theory to minimize the adverse effects. We will apply the theory and conclude with recommendations to help resolve the problems of conventional arms sales in the post-cold war.

Thesis

Arms control is ruled by Chaos Theory. We can use Chaos Theory to understand the effects of Chaos on arms control. Taking an effects-based approach, we will develop a new paradigm for arms control in the post-cold war era, identify the proper balance between US conventional arms control and US arms sales, and determine the proper role of conventional arms control negotiations and agreements.

Methodology

We interviewed experts from the Joint Staff, State Department, Office of the Secretary of Defense, industry, and academia. We participated in State Department training to get an inside understanding of the “real-world” problems implementing arms control policy. Finally, we carried out an extensive review of positive, negative, and centrist views of arms sales as well as both high (applied) and low (mathematical) level Chaos Theory literature.

In our research we found little information that translated Chaos Theory into humanistic applications or interpreted the mathematical concepts into the non-numerical, social universe. During our interviews, we noted the Chaos experts all had extensive mathematical backgrounds and tended to relate to our concepts numerically.

We built upon Diana Richards, “Is Strategic Decision Making Chaotic?”, Meyer-Kress and Grossman’s “Chaos in Arms Control,” and Tagarev, Nicholls et. al., “Chaos in War” studies. Richards quantified decision making and showed that aspects of strategic decision making do display Chaos. Mayer-Kress’s study on Chaos in Arms Control quantitatively showed the levels of arms sales are Chaotic. Tagarev et. al. showed Chaos existed in the strategic, operational, and tactical levels of warfare by analyzing World War II casualty data, Vietnam War aircraft loss data, and US defense spending data. Each study quantified the results of selected social systems and deduced the associated decision making was Chaotic. Our research builds on these studies to show decision making influenced the Chaotic results *proven to exist in their systems*. In effect, we attempt the opposite approach: prove the process is Chaotic to inductively determine effects.

Thus, we began by identifying how the decision-making process in arms control is Chaotic. We looked at the system from a high level, remaining consistent with the mathematical theory. We ensured consistency both vertically (each individual part of the application) and horizontally (the interaction among the parts) to accurately reflect the mathematical concept.

Our first goal is to show some adverse effects of recent US arms control policies. Our second is to synthesize a new application of Chaos Theory to decision making and

show that arms control is a Chaotic process. Once these goals are met, we will use the results to identify considerations for US arms sales policy in the post-cold war.

Notes

¹ Anne Gilks and Gerald Segal *China and the Arms Trade*, (New York: St Martin's Press, 1985), 1.

² <http://tesuque.cs.sandia.gov/~bbooth/docs/marshallplan.html>.

³ Major Charles B. Shotwell, "US Foreign Military Sales After Europe 1992: Reconsidering Market Strategies,," *DISAM Journal* 12, no.2, (Winter 1989-1990): 86.

⁴ Louscher, David J., "The Rise Of Military Sales As a U.S. Foreign Assistance Instrument,," *Orbis* 20, (Winter 1977): 934.

⁵ *The International Peace Directory*, (Plymouth, United Kingdom: Northcote House Publishers, 1988), 138.

⁶ David Wilkinson, *DEADLY QUARRELS, Lewis F. Richardson and the Statistical Study of War*, (Berkeley, Calif., University of California Press, 1980), Table 1, p. 12; and Sq Ldr Sam Alletoy, et. al., "Planning and Execution of Conflict Termination," Research Report no. 95-05, (Maxwell AFB, Ala.: Air Command and Staff College, 1995), 124-125, and Robert Famighetti, ed., *The World Almanac and Book of Facts, 1996*, (New York: Funk and Wagnells and Company, 1995), 486.

⁷ US high; 1995 level is \$12.45 billion. (Lora Lumpe, "Clinton's Conventional Arms Export Policy -- So Little Change," *Arms Control Today*, May 1995, 9).

SIPRI Yearbook of World Disarmament, 1968/69., Stockholm International Peace Research Institute, (Stockholm: Humanities Press, 1969), table 1C2. and *ARMS SALES MONITOR #31*, 5 Dec 95, <http://fas.psych.nwu.edu/fas.files/asm/Dec95.html>.

⁸ The same argument can be made for the introduction of the machine gun just prior to WWI; however, the significant increase in deaths only spiked during WWI and WWII before returning to its pre-war (post-1850) levels.

⁹ Wilkinson, 12, and Col T.N. Dupuy, *Numbers, Predictions and War: Using History to Evaluate Combat Factors and Predict the Outcome of Battles*, (Fairfax, Va.: Hero Books, 1985), 9.

¹⁰ Dupuy, 9.

¹¹ Wilkinson, 12.

¹² *Ibid.*, Appendix 5, 132-142, and Melvin Small and J. David Singer, *Resort To Arms, International And Civil Wars, 1816-1980*, (Beverly Hills, Calif: Sage Publications, 1982), table 6.2, 124, and Alletoy, et. al., 124-125, and *The World Almanac and Book of Facts 1996*, 486.

Chapter 2

Recent US Arms Sales Policies—The Decision Maker's Dilemma

Arms control anywhere consists of an effort to combine the idealism based on hopes for a less dangerous world with the realism of the conflictual nature of the international system.¹

Born from the ashes of WWII, conventional arms sales matured during the bipolar competition between the United States and the Soviet Union. Each subsequent US President put a different emphasis on this tool to help counter Soviet aggression. Very few Presidents, however, succeeded as well as Truman and the Marshall Plan. Ensuing administrations ran into significant pitfalls and continued to fuel the outcry against weapons sales. A quick look at the problems that recent US arms sales policies encountered show the results do not always meet expectations.

In the early 1970s, President Richard Nixon increased the emphasis on arms sales as a major policy instrument. Under the Nixon Doctrine, Washington provided weapons to regional allies as a means of strengthening stability without relying on the deployment of US troops. In the Persian Gulf, a major focus of American policy, the US sold Iran and Saudi Arabia billions of dollars in weapons. In total, the Shah of Iran purchased \$20 billion in weapons, spare parts, and related services from the US between 1970 and 1978—"all justified in terms of deterrence and security."²

“Sending arms instead of troops offered the Nixon administration a way to exert military influence throughout the 3rd world without taking on the political risks or paying the economic costs involved and direct military interventions like the one in Vietnam.”³

His policy was pragmatic in nature and reflected the Vietnam experience on American culture. “Nixon was simply searching for a cheaper, less politically contentious way to maintain the US role as global policeman, fighting the spread of socialist and nationalist regimes in the third world in the name of containing the Soviet Union.”⁴

Nixon’s support to the Shah benefited the US in many respects, including influence and access to the vital Persian Gulf region, access the Soviet Union was unable to procure. After the Shah fell, however, his billion-dollar arsenal of the most advanced weapons in the world fell into the hands of the unpredictable and destabilizing government of the Ayatollah Khomeini. The instability created by the rise of the Ayatollah led to the bloody, eight-year, Iran - Iraq War. A highly condemned war that lasted eight years, cost countless civilian lives, and involved US built weapons.

Nixon’s arms control policies also resulted in a legacy of armed aggression by US-backed countries such as: “Iran’s intervention in the civil war in Oman, Indonesia’s illegal occupation of East Timor, Morocco’s invasion of Western Sahara, Turkey’s invasion of Cyprus, and Gen Augusto Pinochet’s reign of armed terror in Chile.”⁵

On the other side of the spectrum is the Carter Administration, whose goal was a major reduction in US arms sales. President Carter believed arms sales were inherently negative in nature and detracted from the economic and social development of recipient countries, resolved to make arms sales the exception rather than the rule.⁶

“My commitment to the American people [is] that year by year, completely contrary to what we’ve done in the past, we’re going to cut down each year the quantity of arms we sell overseas. I’m committed to doing this, and I’m going to do it.”⁷

President Carter’s commitment was insufficient to limit growth of US arms sales. Under the Carter Doctrine, US arms sales did initially decrease, but eventually rose to a record-level \$18.2 million in 1979. In fact, the hallmark of the Carter administration was the multi-billion dollar arms credits given to Egypt and Israel for signing the Camp David Peace Accords. A result, completely contrary to the stated policy, that earned him the Nobel Peace Prize. Carter also sold Iran the last of the US weapons they used during the Iran-Iraq War.

The Reagan administration’s conventional arms sales policy was diametrically opposed to the Carter Doctrine. Reagan believed arms sales were integral to countering growing Soviet influence abroad.

“The United States therefore views the transfer of conventional arms and other defense articles and services as an essential element of its global defense posture and an indispensable component of its foreign policy.”⁸

“The United States must, in today’s world, not only strengthen its own military capabilities, but be prepared to help its friends and allies to strengthen theirs through the transfer of conventional arms and other forms of security assistance.”⁹

The goals of Reagan’s policy were a direct throwback to the Marshall Plan. It included, in part: “restoration of a greater degree of global stability and balance that will allow individual societies to develop their own economies and pursue their own political and social destinies in peace free of outside intervention or coercion.”¹⁰

According to official statements, Reagan intended the arms policy as an expression of political resolve, particularly against the Soviet Union.¹¹ The policy was a demonstration of political resolve directly from the Nixon mold and expressed the true complexity of the arms sales system. Instead of arming a future rogue state, as was the case with Nixon, Reagan's arms transfers to Afghanistan accomplished practically every short-term goal desired. Selling Stinger surface-to-air missiles to the Mujahidin forced the Soviet Union to withdraw from Afghanistan, provided US influence in a country bordering Iran, and strengthened strained ties with Pakistan, all without introducing US troops into the conflict.

"Viewed from that perspective, supporting the mujahidin was a high-leverage way for Washington to inflict a defeat on the rival superpower and thwart any further expansionist designs that the Soviet Union may have harbored in the South Asia-Persian Gulf region."¹²

The transfer of weapons accomplished Reagan's overall goal; however, looking deeper, adverse effects begin to emerge. The problems arose—not from selling the weapons, but from who received them. Weapons transferred into the region ended up in the hands of Islamic mercenaries fighting in Afghanistan for the cause. After the war, the mercenaries returned home—to Iran and Libya, as well as their terrorist movements, armed with excess, high-tech US weaponry.¹³ To make matters worse, the Pakistani Intelligence Directorate (ISI) decided who got the weapons transferred through Pakistan. Unfortunately, the preponderance of the weaponry went to a Moslem fundamentalist faction involved in the fight.¹⁴

“The harsh reality is that the United States . . . has helped bring to power in Afghanistan political forces that are nearly as odious as the communists they overthrew. Today, the people of Afghanistan are ruled by a collection of authoritarian warlords and sectarian fanatics.”¹⁵

The policies remain just as problematic today. The Clinton administration’s arms control policy is a dichotomy of emphasis and results. Even though he emphasized arms control during the election, his first year in office (1993) saw a record \$33 billion in sales. Even attributing most of those sales to the Bush administration, Clinton’s policy still indicates an upward spiral.

“Although President Bill Clinton criticized the Bush administration during the campaign for failing to initiate a conventional arms control process, as president, he has now decided that the United States should, in fact, maintain its role as the predominant weapons merchant in the world. In some respects, the new policy—embodied in Presidential Decision Directive (PDD) 34—actually surpasses the Bush administration’s strong commitment to gaining an even larger slice of the global arms market.”¹⁶

Clinton’s attitude towards arms control mirrors both Nixon and Reagan, indicating an upward trend in sales. In PDD 34, he states: “transfers of conventional arms [are] a legitimate instrument of US foreign policy—deserving US government support—when they enable us to help friends and allies deter aggression, promote regional stability, and increase interoperability of US forces and allied forces.”¹⁷

But, unlike Nixon and Reagan, the results defy the predictions. In the March 1995 *Arms Control Today*, Sarah Wakling’s article “Clinton Signs Arms Sales Directive, Dashing Hopes for Reduced Transfers,” notes “When details of Presidential Decision

Directive 34 (PDD 34) were announced February 17, it came as a disappointment to those hoping it would come sooner and would impose more significant limits on arms.”¹⁸

However, under the Clinton administration, US arms sales shrank to \$10.51 billion in 1994 and \$12.45 billion in 1995—a 61 percent decrease from 1993.¹⁹

Although arms sales decreased dramatically, William Hartung, a senior fellow at the World Policy Institute, still argues that in “the 50 largest ethnic and territorial conflicts now under way, the Pentagon’s own statistics demonstrate that US-supplied weapons are present on one or both sides in 45 of these wars.”²⁰

The same policies creating the skyrocketing of sales under Nixon and Reagan caused a sharp decline under Clinton. Even further, taking Hartung’s numbers at face value, the problems from sales continue to fuel the controversy.

Notes

¹ *Opportunities for Conventional Arms Limitations in the Middle East and Persian Gulf*, <http://www.biv.ac.il/~steing/carnegie.html>.

² Ibid.

³ William D. Hartung, *And Weapons For All*, (New York: HarperCollins Publishers, 1994), 22.

⁴ Ibid.

⁵ William D. Hartung, “Nixon’s Children, Bill Clinton and the Permanent Arms Bazaar,” *World Policy Journal* 12, no. 2, (Summer 1995): 25.

⁶ Secretary of State Cyrus Vance, statement to the Senate Committee on Foreign Relations, 2 March 1978, quoted in *DISAM Newsletter* 1, no. 1 (Fall 1978): 12.

⁷ President Jimmy Carter, responding to a question about aircraft sales to Middle East, Spokane Town Meeting, 5 May 1978, quoted in *DISAM Newsletter* 1, no. 1 (Fall 1978): 12.

⁸ Defense Institute Security Assistance Management, “New U.S. Conventional Arms Transfer Policy,” *DISAM Newsletter* 4, no.1 (Fall 1981): 1.

⁹ Ibid.

¹⁰ Undersecretary of State for Security Assistance, Science, and Technology, James L. Buckley, statement to the Senate Foreign Relations Committee, 28 July 1981, quoted in *DISAM Newsletter* 4, no.1 (Fall 1981): 18.

¹¹ “US Conventional Arms Transfer Policy Directive, Jul 8, 1981,” quoted in *DISAM Newsletter* 4, no. 1 (Fall 1981): 1-2.

Notes

¹² Ted Galen Carpenter, "The Unintended Consequences of Afghanistan," *World Policy Journal*, (Spring 1994): 1.

¹³ Tim Weiner, "U.S. Will Try to Buy Antiaircraft Missiles Back from Afghans," *The New York Times*, Thursday, July 24, 1993, A1.

¹⁴ Carpenter, 2.

¹⁵ Ibid.

¹⁶ Lora Lumpe, "Clinton's Conventional Arms Export Policy: So Little Change," *Arms Control Today* 25, no. 4 (May 1995): 9.

¹⁷ Ibid.

¹⁸ Sarah Wakling, *Arms Control Today* 25, no. 2 (March 1995): 29.

¹⁹ *Arms Sales Monitor* 31, (5 Dec 1995): <http://fas.psych.nwu.edu/fas.files/asm/Dec95.html>.

²⁰ Hartung, "Nixon's Children," 25.

Chapter 3

The Decision Making Problem

An ultimate goal of the United States is a world which is free from the scourge of war and the dangers and burdens of armaments; in which the use of force has been subordinated to the rule of law; and in which international adjustments to a changing world are achieved peacefully.¹

In the past two hundred years, even though the lethality of arms and their availability climbed dramatically, wars still occurred at relatively stable rates and intensities. More recently, the past four decades saw both US and worldwide levels of arms sales fluctuate chaotically, yet the onset of war actually decreased. Even if this conclusively proved no correlation between arms sales and war onset rates, there is still the use of US weapons in conflicts around the world to rectify. Efforts to decrease the use of US weapons pose numerous dilemmas, and when attempted, have been ineffective.

Arms sales are extremely difficult to judge since there are no definable norms about the requirements of international security. Most states agree on the goal of preventing nuclear proliferation, however, there is no similar principle applicable to the sale of conventional weapons.² Correspondingly, it is much harder to identify the potential problems resulting from a conventional weapons sale, than a nuclear weapons transfer.³

“A particular sale may be destabilizing or it may restore balance. It may promote an arms race in a region, or it may help deter a potential conflict. “Moreover, what is true in

the short run may not be valid for the longer term. . . . Even when a supplier country has adopted general policy guidelines, *each weapons transfer decision must be made individually, and often it will involve complex judgments and trade-offs.*" (emphasis added).⁴

An example of this dichotomy is the 1988 F-18 sale to Kuwait. During the debate, Congress struggled between adding to the Middle East arms race, and the military, political and economic advantages of selling \$2 billion worth of weapons.⁵

During the Iran - Iraq War, Kuwait required US assistance to protect its tankers. Soon after the reflagging and escort operation, the US sold 40 F-18 aircraft along with assorted air-air and air-ground weaponry to Kuwait. At first look, the policy afforded all the desired political, economic and military advantages. Kuwaiti-US relations remained friendly, Kuwait was more secure, the US gained economic benefits from both the initial sale and follow-on support agreements, and Kuwait maintained regional instability. Two years later, after selling some of our most advanced weaponry, Kuwait was unable to deter a regional aggressor and the US went to war.

The controversy is even more hotly contested today. The breakup of the Soviet Union and the end of the Cold War made the United States the world's largest seller of weapons.⁶ It also erased the only recognizable and relatively acceptable paradigm for conventional arms sales policy. In addition, the perceived adverse effects of past arms sales combined with the lack of any major threat all combine to make conventional arms control a political policy *with little precedent*. Given this context then, what is the future of conventional arms control? Should the US continue to sell arms? How much and to whom? Should we limit arms sales? If so, how? And to what level?

Although US arms do not affect the overall rate or intensity of war, the use of US-manufactured weapons in conflicts around the world continues to create controversy. This leads to the crux of the matter: *“How to pursue a conventional arms control policy and minimize adverse effects.”* The answer comes from understanding the underlying principles that create such apparently unpredictable effects of policy. Understanding these principles will help limit the adverse effects and lead to development of a useful arms control policy.

Chaos Theory as an Answer

In order to minimize adverse effects of arms sales, we need to understand how adverse effects arise. As the studies by Grossman and Meyer-Kress, Richards, and Tagarev all showed, quantifiable results of some decision making exhibit Chaotic aspects. This Chaos can be a fundamental cause of unpredictability and adverse effects in the decision-making system. We will briefly describe Chaos Theory, then show its application to decision making.

Chaos Theory describes non-linear, non-periodic, deterministic but unpredictable systems. Taking that definition piece by piece, we will first look at the pure, mathematical definitions, then see their applications to decision making.

Linear: The process by which the output is proportional to the input. $2a=b$ is a linear equation; if the input (“a”) is changed, the output (“b”) will reflect a corresponding change; hence, $2a=2b$. **Nonlinear** is a process where a change in the input is not reflected by a proportional to the change in the output. $a^2=b$ is nonlinear. Doubling “a” does not double “b” ($2^2=4$, however, $4^2\neq8$).

Non-periodic: The function is non-repeating. Each successive calculation results in a unique answer. **Periodic** functions repeat answers in an identifiable pattern.

Deterministic: The system has a single result for each input. **Nondeterministic** systems do not have a result, or the result is ambiguous (more than one result for any input).

Predictable: The result of a system can be calculated. The result of an *Unpredictable* equation cannot be calculated.

Therefore, Chaotic systems are non-linear, so the output is not proportional to the input; deterministic, so each input results in a single output; but unpredictable, so results cannot be calculated with finite precision. How does this apply to decision-making? In a nutshell, Chaos Theory describes systems whose outputs are neither random, nor directly calculable—the very essence of decision making.

Applied Chaos Theory

We will begin by establishing, as our basis, that Chaos Theory affects decision-making. We will describe basic states of dynamic decision-making and show the application of Chaos. We will then show the function of strange attractors, the effect of initial conditions, how to measure stability, and finally how to identify and use control parameters.

We can make a direct correlation between most types of decision-making and a mathematical system. For the purposes of this study, however, we will limit ourselves to the following two:⁷

Linear

Mathematically. A deterministic system based on addition, subtraction, multiplication, or division.

Decision Making. Linear decisions are ruled by a flow chart or logic tree. If you want to hear music, “turning on the radio” is a linear decision. The result is proportional to the decision—and changes in the decision are mirrored by corresponding changes in

the result. The faster you turn on the radio, the faster you hear music. If you turn the volume down one step, the sound will lower correspondingly.

Discussion. Linear decision-making uses step-by-step logic and relies on “if-then” type logic. A decision-maker identifies the current situation, applies a rule to determine the next step, and repeats the process. Linear decision-making is also the foundation of computer decision-making. A computer applies specific rules to an input to determine a result. Regardless of the computer or the context, the same input will always produce the same result.

Chaotic

Mathematically. Non-linear, non-periodic, deterministic, unpredictable systems.

Decision Making. Decisions requiring understanding of a current situation and anticipation of a non-quantifiable result. The end state can be described in general terms (predicted), but exact details are impossible to determine (incalculable).

Discussion. Chaotic decisions are the true essence of decision-making. A decision maker internalizes the input and makes a decision. The decision is based on factors which cannot be completely identified, and small changes (attitude, information, stimuli, etc.) may result in different results. Choosing a course of action to defeat the Iraqi military during the Gulf War is Chaotic. There are an infinite combination of factors, (exact troop strengths, final position of friendly and enemy forces) that, in total, satisfy the objective. Therefore, the result of the decision (Iraqi military defeat) is predictable, but not exactly calculable.

In Chaotic decision-making, the system is defined as the process whereby time acts upon a set of initial conditions to determine a result. It is a dynamic, and continual

system with the initiation of the system (time=0) designated as the time of the decision. The decision modifies the initial conditions in an attempt to reach a desired end state. As a more descriptive definition, life is a set of conditions that continually change with time. If we freeze any one instant (and can identify all the information) we can describe all the conditions that exist at that moment. A “decision” lets us change one of those conditions, so as time passes, the conditions (results) at a later point in time meet our goals.

The decision-making identifies the type of system. Linear systems use linear decision-making. They are a step-by-step process, learned by memorization, and do not require experience to perform well. Alphabetizing is linear decision-making—a person looks at a letter and decides if it goes before or after a previously identified letter. The result is proportional to the input—if there are 14 names to alphabetize, the result is a list of 14 names. If one more name is added, one more name is alphabetized. I can calculate my result exactly so the system is predictable and deterministic.

Correspondingly, Chaotic systems use Chaotic decision-making. Since all the initial conditions cannot be identified, the exact result cannot be calculated. The earlier example of the Iraqi army illustrates the connection. We can predict the course of action will defeat the Iraqi’s, but a description of the exact conditions that will exist, including number of casualties, force positions, disposition, etc. is impossible. Because the outcome is only predictable and not calculable, there are possibilities for unintended, or adverse, effects.

The behavior of a school of sardines is a visual example of Chaotic decision-making. Thousands of sardines swim together, moving effectively as one body. The movement, *determined by the collective decision making of the sardines*, describes a complex, non-

periodic, deterministic function (mathematically exhibiting three degrees of freedom—x, y, velocity). The next move is not random, but cannot be calculated. Adhering to the very basic Chaos principles—resetting the sardines to their exact starting point will not result in the same path.

Chaotic systems are affected by seemingly insignificant events, unmoved by major input changes, and require decisions based on experience.

The key to applying Chaos Theory to decision-making is understanding the concepts of the attractor, the stability of the system, and the control parameters.

The Strange Attractor and Stability. *Understanding the attractor is the central element of Chaotic decision making.* The attractor is the collection of all possible outcomes. Plotting these outcomes graphically depicts the attractor's size and shape. Like the mathematical application, our decision-making attractor has multiple "wings," or groups of particular outcomes. As a Chaotic system develops, it moves within the attractor. Although the movement is not calculable, knowledge of the attractor's size and shape helps us predict the probable result.

For example, if a situation is currently acceptable, then the system resides in a wing of the attractor described by all acceptable outcomes. If there are a wide variety of acceptable alternatives, this wing will be relatively large. If there are no indications the system is switching into one of the other wings, the next step will probably be acceptable also. (see figure 1)

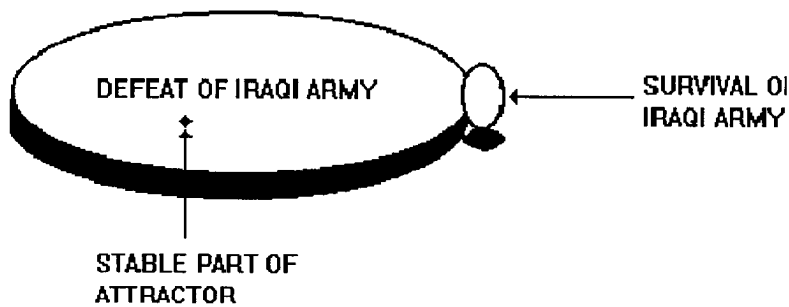


Figure 1. Generic Decision Making Attractor

For Chaotic decision-making, experience is only one way to gain this type of knowledge of the attractor. Experience describes the level of understanding of the attractors size and shape. The greater the experience, the greater the understanding of the attractor, and hence, the more accurate the decision made; conversely, the lower the experience, the less accurate the decision. A “guess” defines a Chaotic decision based on little to no experience. After the guess, the decision-maker analyzes the results and gains experience of the attractor.

Another basic principle of Chaos is the long-term unpredictability. Although information on the attractor’s size and shape allows fairly accurate short-term predictions, long-term results are not as ascertainable. Therefore, further decisions (“changes in the initial conditions”) are necessary to maintain the system in the desired wing of the attractor.

If the system indicates a possible jump into another wing of the attractor, the potential for adverse effects or unintended results increases. This tendency to switch between parts of the attractor is called stability. The greater the stability, the more likely the system will remain in one wing of the attractor; the greater the instability the more

likely the system will change wings. A highly stable system reflects virtually no short-term changes, even if the initial conditions change significantly. Correspondingly, an unstable system may change with only a minor, almost insignificant input.

System stability greatly impacts decision-making. As the system approaches a switch (instability), multiple results will begin to emerge and confidence in the outcome (of the decision) will decrease. (see figure 2)

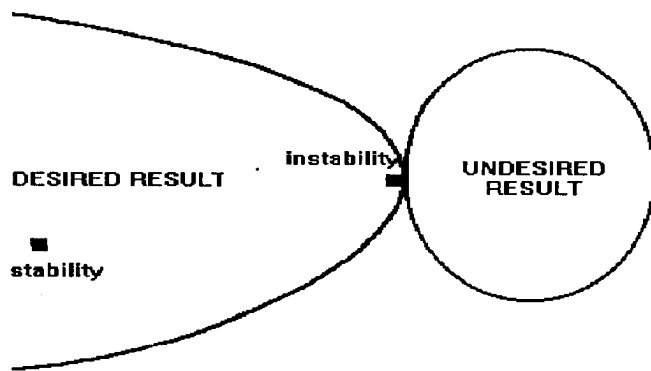


Figure 2. Instability

The Lyapunov Exponent. The “Lyapunov Exponent” is a measure of Chaotic stability. Mathematically, we identify this level of stability by changing the initial conditions and comparing how quickly the outcomes diverge. In our application, since a “decision” creates a change to one of the initial conditions, we can apply the Lyapunov concept to discern instability—the root cause of adverse effects. Using simulation to compare the expected results of different decisions will indicate the level of stability. If the system is stable, there is a greater probability of success. In contrast, if the results diverge quickly, the system is unstable, and the probability of success is decreased. In other words, the greater the stability, the greater the range of decisions available to achieve the goal.

Sensitivity to Initial Conditions (SIC). Sensitivity to initial conditions is a function of both the attractor and its stability. The SIC principle says even a small, imperceptible change in the initial conditions can make a significant change in the result. Since a “decision” is one of the initial conditions, the SIC principle makes it critical to determining the result. An apparently insignificant decision (or even the lack thereof) can create a major change in the result.

The Control Parameter. The control parameters can manipulate the decision-making process. The ability of controls to shift Chaotic systems into linearity, and vice-versa, make them indispensable to a decision-maker.

Feedback and timing are central to James’ discussion of controls. He warns to expect Chaos in any system that incorporates feedback in the process. “We can also change some periodic systems into Chaos by timing inputs to occur before the system has time to relax.”⁸ Applying these concepts to our system, inputs and feedback are both forms of information, implicating it as a control. The proof is to see if the manipulation of information can create Chaos in the decision-making system.

Colonel John Boyd’s Observe, Orient, Decide, Act (OODA) Loop directly proves the point. In his paper, Boyd describes the onset of Chaos. He claims that observing, orienting, deciding and acting faster than an adversary will make his reaction totally inappropriate to the situation. “Such activity will make us appear ambiguous (unpredictable) thereby generate confusion and disorder among our adversaries. . . .”⁹ In his analysis, Boyd determines the key is efficient and effective *orientation*—comprehending events based on observation and feedback (“information”). “Mismatches between the real world and our mental images will generate inaccurate responses.”¹⁰

Boyd's OODA Loop also implicitly addresses the Chaotic effects of timing. Slowing feedback forces an adversary to expand his OODA Loop and become enmeshed in "amorphous, menacing, and unpredictable world of uncertainty, doubt, mistrust, confusion, [and] disorder. . . ." ¹¹ Applying Faydok's model of the OODA Loop, inaccurate feedback, or forcing an enemy to react before feedback arrives have the same effect. ¹²

In his landmark study, Gottfried Mayer-Kress establishes a mathematical version of the OODA Loop as a control. "A non-linear dynamical system will respond . . . to a control force which is close to its own intrinsic dynamics.[observe] If the system is perturbed [decide/act] with such a resonant force [orient] while it in a stable domain, then this form of open loop control can be very effective." ¹³

Chaos Applied to Arms Control

Arms Control is Chaotic

Proving decision-making is Chaotic was only the premise for our thesis. We now must prove the arms control decision-making is Chaotic to identify the proper balance between US conventional arms control and US arms sales and the proper format/forum for conventional arms control negotiations and agreements.

We will build on Grossman and Mayer-Kress who proved the yearly arms sales figures are Chaotic and prove the arms control decision-making that created those figures is Chaotic. Once we prove the system is Chaotic, we will identify the attractors, determine how to identify system stability, and apply the control parameters.

Various arms control experts effectively identify arms control as a Chaotic system. “A model approach to political problems on whose solution even the opinions of reasonable men radically differ cannot be a panacea.”¹⁴ Others identify the need, but feel the task is too daunting because:

1. It has a complex structure which is inadequately understood;
2. The structure is understood, but it involves uncertainty whose relevant probabilities cannot be estimated;
3. The phenomenon appears to be well understood empirically, but there is no known theoretical structure for its representation;
4. The structure is known and well understood, but not solvable even by approximation methods.¹⁵

But how do we *prove* the decision-making system is Chaotic? A system is Chaotic if it is: non-linear, not periodic, expresses sensitivity to initial conditions, and has bounded outputs.¹⁶ If arms sales decision-making displays each of these characteristics, then it follows that arms control is Chaotic.

Non-Linear. As the Nixon, Carter, Reagan, and Clinton policies illustrated, changes to arms control policies are not reflected by a corresponding change to the output. Nixon’s intent to maximize arms sales to support policy resulted in \$16 billion dollars in sales. Carter on the other hand reversed the policy, but obtained the same results. Clinton, using similar arms-advocating policies as Nixon, decreased arms sales dramatically.

Sensitivity to Initial Conditions. Results of arms control policies historically exhibit both little change with major impacts, and major change with little impact. President Jimmy Carter’s policy stated arms sales are the exception rather than the rule. He made major policy changes, yet arms sales did not change significantly. Clinton decreased arms sales 61 percent using minor adjustments to the existing policy.

Non Periodic. Arms control is a time-based, dynamic system integrating feedback. Periodicity would require the system to revert to a previous point in time. Because it *is* contextual, and we accept that no two time periods are exactly alike, the system *must* be non-periodic. Periodicity reflects the result, therefore although decisions can be repeated the results create a contextually based unique set of circumstances

Bounded Outputs. The arms control system is the set of initial conditions acted upon by time using weapons sales as the decision to reach a desired goal. Our outputs are a definition of the desired end states and consist of the universe of possible outcomes. “For instance, relations between two nations may be ‘friendly,’ ‘cordial,’ ‘tense,’ or ‘hostile’ (or whatever), but there is some well-defined range of values that the variable ‘relations’ can take on.”¹⁷

Developing the Arms Control Attractor

Initially, a possible arms control attractor is based on qualitative or quantitative sales. Although complete, it does not “group all possible outcomes.” A more accurate definition for our attractor identifies all possible effects of our decision and groups like outcomes.

US policy delineates our desired outcomes. The current arms control policy lists six primary goals: “Deterring aggression, promoting stability, increasing interoperability, preventing proliferation of weapons of mass destruction, and enhancing the ability of US defense industrial base to meet US defense requirements and maintain long-term military technological superiority at lower costs.”¹⁸ In addition, The Arms Control and Disarmament Agency (ACDA) evaluates weapons transfers to determine if they might:

- Contribute to an arms race,
- support international terrorism,
- increase the possibility of outbreak or escalation of conflict;
- prejudice the development of bilateral or multilateral arms-control arrangements; or
- adversely affect the arms control policy of the United States.
- In assessing export cases, [they] also take into account:
- regional stability and military balance,
- legitimate defense needs relative to threats,
- the military force structure, strategy and doctrine of the proposed recipients and its neighbors,
- whether the transfer would constitute a new offensive, power-projection, or destabilizing capability,
- proliferation implications, and
- risks of misuse or unauthorized retransfer.¹⁹

The complete attractor combines all the objectives and identifies all possible outcomes. President Clinton's policy states six goals, so the attractor theoretically is six-dimensional. For our purposes, we will narrow the focus to one objective. We will start with "stability" since it is the most prevalent concept presented throughout the literature.

Since the decision to sell a weapon is contextual, we need to identify a more specific end state. Stability is useful to describe a political concept, but too ambiguous as a goal to build a usable attractor. In his book, Colin Gray describes four major varieties of stability in political science:²⁰

1. *Crisis stability*. The likelihood a political conflict will lead to war even though both sides prefer to remain at peace.
2. *Arms race stability*. The rate of change in competitive armaments and the perceived need to introduce new, or more, weapons.
3. *Weapon-system stability*. The destabilization of a particular weapon system (MIRVs/ASAT/ABM, etc.).
4. *Political stability*. The propensity to fight in particular international relationships.²¹

We will choose “political stability” as the goal for our scenario. Therefore, the attractor has two possible outcomes (two-dimensional), and therefore, two wings: political stability and political instability. (see figure 3)

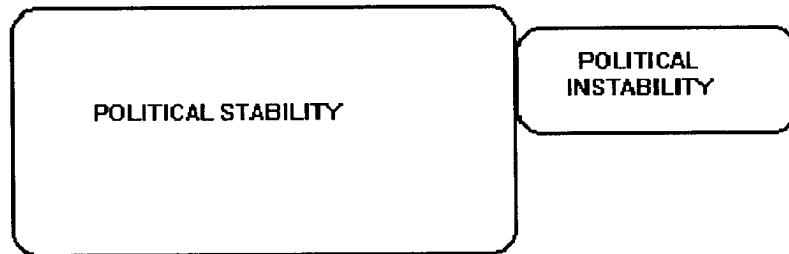


Figure 3. Generic Arms Control Attractor

Desired facets are defined as “positive wings,” undesired ones as “negative wings,” and neutral facets as “neutral.” In our arms control system, we will assume political stability is positive (desired) and political instability is negative (undesired). In reality, we cannot assume any wing of the attractor is positive or negative since it depends on the context. For example, the US attractor should have reflected political stability of the Allies towards Germany as negative (indicating a desire to increase conflict) in the years leading up to World War II.

Once we define the attractor, we must identify the relative densities (comparative sizes) of each wing. Assume, for example, the US wants to sell T-37 trainers to Great Britain in today’s political environment. Our positive wing (political stability) is very large compared to the negative. The T-37s are not militarily provocative, nor is there anything to suggest Great Britain will adversely use the aircraft. (see figure 4) Change the scenario to South Korea or India receiving the Stealth fighter, and the attractor changes significantly. The negative wing becomes large, the positive small. (see figure 5)

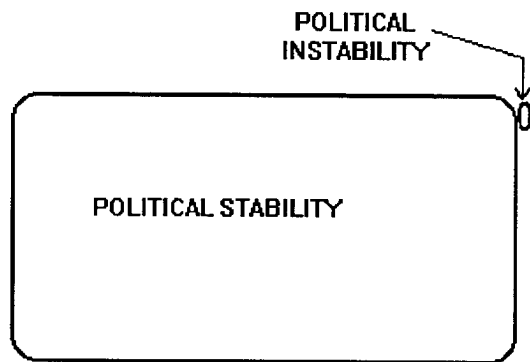


Figure 4. Potential T-37 Sale to Great Britain Attractor

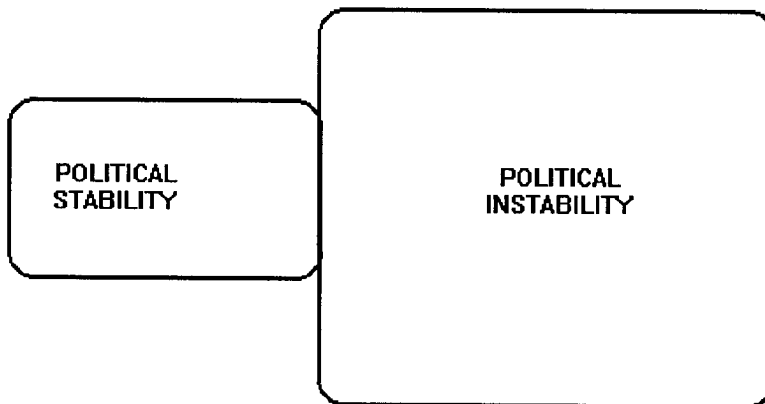


Figure 5. Potential Sale of F-117 to South Korea/India

Finding and applying the Control Parameters. Once we specify the goals and the describe the attractor, we need to identify how to avoid adverse effects.

“One crucial skill for any decision maker is the ability to identify all the parameters accessible to external control and to isolate those parameters that have the greatest influence on a system.”²²

Controls are the second most important concept in Chaotic decision making. Typically, in decision making, if the attractor is stable, we anticipate the successful short

term results. If the system exhibits instability, indicating a possible undesired result or adverse effect, we can use controls to make the system linear.

Since linear systems are more predictable, we can more accurately determine the correct decision. North Korea declaring it will pre-emptively attack South Korea if it buys the stealth fighter, creates a linear arms control decision-making system. We can exactly calculate (map on a logic tree) the results of our decision. If we want to avoid war, we do not sell.

Controls also move the system from linearity to Chaos. In our North Korea example, we cannot sell the stealth fighter and avoid war unless the system shifts out of linearity. Once it shifts into Chaos, an experienced decision-maker can identify when the system stabilizes in the desired wing and take that opportunity to sell the aircraft.

Making Arms Control Linear. Linearity is the ability to determine the outcome of every input. Two controls appear to allow the prediction of political instability in arms control: treaties and information.

Treaties, as intended, make the system linear and predictable. If situation X occurs, by treaty, Country Y can react accordingly. Treaties can limit the levels or the types of conventional weapons sold to a particular country or region. Treaties provide a linear decision point and hence, the ability to calculate the result.²³

Koulik, in his book *Conventional Arms Control*, says “the *predictability* resulting from far-reaching arms control accords and other arrangements can help to alleviate the domestic and international impetus for such destabilizing activities in the military arena.”²⁴

As a control, however, conventional arms control treaties are extremely difficult to use. The efforts to limit conventional arms sales in the Middle East demonstrate the problems. In August 1949, the US, France, and Britain announced a coordinated effort to regulate the flow of arms to the region. In May 1950, the Near East Arms Coordinating Committee (NEACC) formalized the “Tripartite Declaration.” However, the extensive regional interests of all three countries, the competition between them, and the failure to include the USSR as well as other major suppliers, weakened its effectiveness. The language of the declaration also included significant loopholes, permitting the acquisition of arms “to maintain a certain level of armed forces to assure their internal security and their legitimate self- defense.”²⁵ Unfortunately, both suppliers and recipients exploited the undefined “certain level of armed forces” for each state. Other efforts brought on by the 1967 and 1973 Arab- Israeli wars, also failed to solve the problem posed by the need to maintain the balance of power and to provide arms to clients.²⁶

Conventional arms sales are an arm of foreign policy among competing nations, so limits are improbable. Writing in *Foreign Affairs*, Alvin Rubenstein says “Limitations would have to be accepted and implemented by Russia, Britain, France, Germany, Italy, China, North Korea, and other suppliers. The Bush Administration’s September 1992 announcement of the sale of F-16 aircraft to Taiwan brought an angry reaction from China. The government in Beijing announced a boycott of the negotiations on arms transfers conducted under the P-5 framework, and to increase sales to the Middle East and Persian Gulf.”²⁷

China’s arms sales policy, for example, is diametrically opposed to the West. China uses weapons transfers to rapidly gain influence in areas neglected by the “Top 6” arms

exporting countries (United States, United Kingdom, Russia, Germany, China and France).²⁸ “The Chinese see their role as leading the united front of small and medium powers against the hegemony of the superpowers.”²⁹ China looks upon arms sales limitations by the “Top 6” as an opportunity to further their foreign policy. “In the late 1980s, China became Iran’s second leading arms supplier, and contracts have been signed for two (or, according to some reports, six) billion dollars in weapons. These transactions include “tens” of F-6 and F-7 aircraft (equivalent to the MiG-19 and MiG-21), improved T-55 (known as Type-69) tanks, artillery, APCs, and anti-aircraft systems.”³⁰

The French national security strategy, on the other hand, demands a high level of arms exports. France believes an independent arms industry is key to projecting their influence internationally, as well as essential to an autonomous defense policy.³¹

“To the maximum extent feasible, it is argued, France must have the capability of equipping its own armed forces without depending upon an uncertain source of supply from abroad. In order to maintain this ability to arm itself, France must export weapons, as the demand at home is not enough to justify the arms industry in economic terms.”³²

France’s cultural perspective on arms sales is not unique. Their emphasis on maintaining a share of the export market in fact, mirrors US arms sales attitudes.

“If we do not sell the F-18 then Kuwait will buy a foreign made aircraft, probably either the Mirage 2000 or the Tornado, and it is not inconceivable the [Russians] may offer the MiG-29. In either case we would lose the benefits that go along with the sale of a US product, both economic and military, as well as political.”³³

Russian arms sales policy comes from a different perspective. The new Russian leadership is committed to transforming its political system and developing a market

economy. Unfortunately for the Russians, the transition to a system based on democratic and market concepts are proving to be very difficult. Arms exports are one of Russia's few commodities capable of providing hard currency and shoring up its severe foreign debt.³⁴

“In an effort to increase income, and hard currency wherever possible, the Soviet Union, and now Russia, ended its grant military aid program with most of its Third World arms customers. At the same time, Russia has sought weapons contracts with countries such as Iran that can pay either in hard currency or a marketable commodity such as oil.”³⁵

Russia is also increasing its arms sales with former adversaries (China), traditional Western customers (Malaysia and the United Arab Emirates), and traditional partners such as India.³⁶ However, even with these efforts to sell advanced weapons systems at competitive prices, Russia's political situation is inducing potential buyers to look to the West.³⁷

In addition, the parties to any arms agreement must define the quantitative and qualitative limits. As noted earlier, this poses a number of difficulties, including the definition of stability and international security. “The downfall of the Tripartite Declaration and the Near East Coordinating Committee (1950-1955) was undermined by the failure to agree on the definition of requirements for a ‘stable balance of power’ and for ‘legitimate self defense.’”³⁸

Moratoriums, as extreme forms of limitations, are rarely successful for the same reasons. The “Top 6” arms producing/exporting countries are a politically diverse group whose goals are often irreconcilable. Compounding the problem are the “niche”

countries—the bottom 10 percent of the arms producers (North Korea, South Africa, Israel)³⁹ who rely on sales into areas abandoned by the “Top 6.” Thrown into the fray are the top eight non-aligned, third-world, arms producers who make 140 types of major weapons systems (65 types of aircraft, 15 types of armored vehicles, 30 missiles and 30 warships).⁴⁰

Short term embargoes are not immune to the problems. Recently even the US, one of the most vocal supporters of the Bosnian Muslim arms embargo, covertly sent weapons to the Balkans.⁴¹

The second control, “information,” gives a more accurate indication of the position and stability of the system within the attractor. In our arms control example, it means accurately identifying the political stability and potential for adverse effects. The information “North Korea will go to war if South Korea acquires the F-117” makes the system linear.

“The first stage in any Middle East arms control process is widely expected to be limited to the implementation of modest confidence building measures, as discussed in the meetings of the multilateral working group on arms control.”⁴²

For more than a year the five permanent members of the United Nations Security Council (US, United Kingdom, Russia, France, and China) debated on whether to notify each other about prospective arms sales to the Near East. The US wanted to establish on-going consultations to possibly curtail “destabilizing arms sales” to the region. However, by the fall of 1992, the discussions effectively collapsed when China ended its participation after the United States sold 150 F-16s to Taiwan.⁴³

As we saw earlier, if the linear system is not leading to our end state, we may want to shift the system into Chaos. “Instead of attempting to force the system to the desired state, one can use the information about the geometrical structure of the attractor of the system to drive the system close to a stable manifold of the goal state. Then the internal dynamics will assist in bringing the system closer to the desired state.”⁴⁴ In our scenario, if the linear system does not lead to political stability, we need to create Chaos and let the dynamics shift the system towards our goal.

Using a control to create a linear system is not always beneficial, as the rearmament of Germany during the 1930's illustrates. Hitler signed the “Anglo-German Naval Treaty” limiting the German surface navy to 35 percent of the British and parity in submarines. The treaty made the buildup decision linear. As long as the British knew Hitler was below the agreed numbers, they *perceived* political stability. The German perspective preferred linearity. Since Hitler knew it would be years before he reached those numbers, he used the treaty solely to guarantee his decisions to rebuild the navy would go without confrontation. “. . . the treaty helped to convince the British leaders that they could do business with Hitler.”⁴⁵ From the British perspective, Chaos was the better choice.

Putting the System Into Chaos. “Chaos sets in when the system has no time to relax.”⁴⁶ Relaxing involves time to accurately assess the situation and make a correct decision. If a decision-maker does not accurately assess the situation, the step-by-step linear process breaks down and the next step cannot be identified. Therefore, making the decision maker *react before he has time to assess the situation (relax)* will put the system into Chaos.

“One of the basic needs for military-political stability . . . is predictability of military developments as a means to eliminate short- and long-term security concerns. Such predictability continues to be the principle requirement for the further strengthening of security. . . . The past record has shown the vicious circle of action-reaction in military preparations. Predictions or perceptions by one state of ‘bad intentions’ on the part of another state or groups within a state could prompt reactions which might also be implemented without the ability to predict counter-reactions.”⁴⁷

Returning to our example of the rearmament of Germany WWII, Hitler knew the linear arms control decision-making system created to rebuild the navy, would not favor rebuilding his air force. He therefore needed to shift the system into Chaos and let the system fall naturally into his desired attractor. He controlled information and limited Britain’s knowledge of the in the system, creating a situation where their lack of current knowledge of the attractor led to an undesired result. Bogus military manuals were printed for inspection, hunting clubs, civilian police, and private paramilitary organizations provided military training and equipment for large numbers of men. Germany augmented its arms production capability by clandestinely purchasing European heavy-industry manufacturing firms exporting weapons to Spain and Turkey.⁴⁸

“Nazi Germany had secretly and unlawfully created a military air force which, by the spring of 1935, openly claimed to be equal to the British. She was now in the second year of active munitions production after long covert preparations.”⁴⁹ Churchill felt Britain had, at any time during the buildup of Germany, capability to stop Hitler, but failed to interfere.⁵⁰

“Up until the middle of 1936 Hitler’s aggressive policy and treaty breaking had rested, not upon Germany’s strength, but upon the disunion and timidity of France and Britain. . . .”⁵¹

Information has cascading effects. Once the system becomes Chaotic, the adversary’s decreased knowledge of the current state of the system within the attractor increases the chances of an adverse effect. Secondly, Chaotic decisions are not linear, so the effects of even a minor error can create major problems.

Sometimes misperceptions prevent war, e.g., if states are insecure but don’t know it they may refrain from wars they might start if they knew the truth. However, it’s often true that misperceptions on either side of the reality baseline raise the risk of war, e.g.:

- Exaggerating or underestimating others’ hostility can cause war.
- False optimism or false pessimism can cause war.⁵²

The United Nations is trying to use controls to minimize the adverse effects of arms sales. The Transparency in Armaments Agreement is an information-based treaty designed to help countries evaluate the effect of arms sales. It is a very insightful step, however, the most controversial aspects of the agreements loom even larger given a Chaos perspective: the sales reporting is strictly voluntary, so the agreements facilitate the use of information to manipulate the system as a control; and the agreement only emphasizes major weapons systems. Small arms, automatic weapons, land mines etc., are not reportable under the conventions, so only partial knowledge of the attractor is available.⁵³ Although it is a commendable first step, the combination of these problems set the agreement up for failure. They provide a manipulating control, and the tools to facilitate its use.

Notes

¹ Public Law 87-297. September 26. 1961 "The Arms Control and Disarmament Act."

² Andrew J. Pierre, "Arms Sales: The New Diplomacy," *Foreign Affairs* 60, (Winter 1981/1982): 270.

³ Majors Gil Castillo, Taylor Kunkle, Tom Billick, Scott Roenicke, and Chris Mapletree, HQ USAF/XOXI, interview with author during visit to Pentagon, Washington, D.C., 2 February 1996.

⁴ Pierre, 270.

⁵ House, Proposed Arms Sales to Kuwait: Hearing Before the Subcommittees on Arms Control, International Security and Science, and on Europe and the Middle East of the Committee on Foreign Affairs," 100th Cong, 2nd sess, 1988, 24.

⁶ *SIPRI Yearbook, 1995: Armaments, Disarmament and International Security*, (New York: Oxford University Press, 1995), table 14-1.

⁷ Other decision-making systems we can model include random, fixed, and periodic. (Bruce DeBlois, "Deterministic Philosophical Assumptions in the Application of Chaos Theory to Social Events," Unpublished Research Report, (Maxwell AFB, Ala.: School of Advanced Airpower Studies).

⁸ Major Glenn James "Chaos and Campaign Planning," lecture, Air Command and Staff College, Maxwell AFB, Ala., 8 March 1996.

⁹ John R. Boyd, "A Discourse On Winning And Losing," (A collection of unpublished briefings and essays), August 1987, 5.

¹⁰ Major David S Fadok, "John Boyd and John Warden, Air Power's Quest for Strategic Paralysis," School of Advanced Aerospace Studies, (Maxwell AFB Ala.: Air University Press, 1995), 17.

¹¹ Boyd, 134.

¹² Faydok, 16.

¹³ Gottfried Mayer-Kress, "Conflict in International Systems," unpublished paper based on talk presented at SHAPE Technological Symposium on Crisis Management, Mons, Belgium, 1992, 5.

¹⁴ Roger P. Labrie, John G. Hutchins, and Edwin W.A. Peura, *US Arms Sales Policy Background and Issues*, (Washington, D.C.: American Enterprise Institute for Policy Research, 1992), 10.

¹⁵ Thomas L. Saaty, *Mathematical Models of Arms Control and Disarmament. Application of Mathematical Structures in Politics*, (New York: John Wiley and Sons, Inc., 1988), 8.

¹⁶ Major Glenn James, *Chaos lecture* videotape, Air University TV, 1994.

¹⁷ Major Glenn James letter, subject: Chaos in Decision making, 27 March 1996.

¹⁸ Office of the Press Secretary, "FACT SHEET Conventional Arms Transfer Policy," The White House, 17 February 1995.

¹⁹ U.S. Arms Control and Disarmament Agency, "Threat Control through Arms Control," Report to Congress, 1994, 37.

Notes

²⁰ Gray also attacks the notion of arms race stability: "What can be meant by a stable arms race? The idea of stability in arms racing challenges any reasonable definition of an arms race."

²¹ Colin S. Gray, *House of Cards, Why Arms Control Must Fail*, (Ithaca N.Y.: Cornell University Press, 1992), 58-59.

²² Major Glenn E. James, "Chaos Theory: The Essentials for Military Applications," Research Report, (Newport, R.I.: Naval War College, 1995), 41.

²³ We assume the treaty is an effective, developing valid treaties to prevent instability is also Chaotic, but outside the scope of this study.

²⁴ Sergey Koulik and Richard Kokoski, *Conventional Arms Control, Perspectives on Verification*, (New York: Oxford University Press, 1994), 6.

²⁵ *Opportunities for Conventional Arms Limitations in the Middle East and Persian Gulf*: <http://www.biv.ac.il/~steing/carnegie.html>.

²⁶ Ibid.

²⁷ Ibid.

²⁸ *SIPRI Yearbook, 1995: Armaments, Disarmament and International Security*, (New York: Oxford University Press, 1995), Table 14-1.

²⁹ Gilks and Segal, p 84.

³⁰ *Opportunities for Conventional Arms Limitations in the Middle East and Persian Gulf*: <http://www.biv.ac.il/~steing/carnegie.html>.

³¹ "If you want to be able to afford to make your own weapons, you have to be able to sell them." French Minister of Defense Pierre Joxe, quoted in *The Washington Post*, Apr. 6, 1991, A17.

Andrew J. Pierre, *The Global Politics of Arms Sales*, (Princeton N.J.: Princeton University Press, 1982), 84.

³² Ibid., p 274

³³ Statement of Edward W. Gnehm, Jr., Deputy Assistant Secretary for Near Eastern and South Asian Affairs, Department of Defense, House, *Proposed Arms Sales to Kuwait*, 14.

³⁴ *Opportunities for Conventional Arms Limitations in the Middle East and Persian Gulf*: <http://www.biv.ac.il/~steing/carnegie.html>.

³⁵ Ibid.

³⁶ Ibid.

³⁷ Ibid.

³⁸ Ibid.

³⁹ *SIPRI Yearbook, 1995: Armaments, Disarmament and International Security*, Table 14-1.

⁴⁰ Frank Barnaby, *The Role And Control Of Weapons In The 1990s*, (London: Routledge Press, 1992), 21.

⁴¹ Michael Dobbs, "Saudis Funded Weapons For Bosnia, Official Says, \$300 million Program Had U.S. 'Stealth Cooperation,'" *The Washington Post*, Friday, Feb 2, 1996, p 1.

⁴² *Opportunities for Conventional Arms Limitations in the Middle East and Persian Gulf*: <http://www.biv.ac.il/~steing/carnegie.html>.

Notes

⁴³ Richard F. Grimmett, "Conventional Arms Transfers in the Post-Cold War Era," [gopher://gopher.cdi.org:70/0/atdb/patterns/analysis/93-852f.txt](http://gopher.cdi.org:70/0/atdb/patterns/analysis/93-852f.txt)

⁴⁴ Mayer-Kress, 5

⁴⁵ Larry H. Addington, *Patterns of War Since the Eighteenth Century*, (Bloomington, Ind.: Indiana University Press, 1994), 175.

⁴⁶ Major Glenn James, "Chaos and Campaign Planning," lecture, Air Command and Staff College, 8 March 1995.

⁴⁷ Koulik, p 6.

⁴⁸ Patrick Glynn. *Closing Pandora's Box, Arms Races, Arms Control, And The History Of War*, New York: New Republic Books, 1987), 63.

⁴⁹ Winston S. Churchill, *Memoirs of the Second World War*, (Boston: Houghton Mifflin Company, 1987), 87.

⁵⁰ History is replete with examples of Chaotic instability in the decision making systems of both France and Great Britain with regard to the rearmament of Germany. Churchill illustrates many.

⁵¹ Ibid., 47

⁵² Ibid., 94.

⁵³ Van Evera, Shapiro & Valentino, "National Misperception and the Causes of War," Internet address: <http://cis-server.mit.edu/DACS/milper.html>.

⁵⁴ Sarah Wakling, "FACTFILE, 1993 UN Conventional Arms Register," *Arms Control Today*, January/February 1995, p 29-30.

Chapter 4

Conclusion

*War is merely the continuation of policy by other means.*¹

Clausewitz' timeless maxim identifies one of the fundamental truths of war. In it lies the ultimate support for the results of the application of Chaos to arms control.

Chaos can be applied to decision making, remain consistent with the mathematical theory, and have significant implications. *The results show the focus is not on the weapons, but the fundamental political policies guiding their use.* "Countries arm in order to deter, to defend if they must, and sometimes to secure the assets of others, but they do not fight because they are armed."²

Our study began with a look at the growth of arms sales. We saw proof arms sales have no quantifiable effect on the rate and intensity of war. We continued with a look at arms sales policies of selected US Presidents and saw the unpredictable, adverse effects of the weapons sales. We combined this information with previous studies proving Chaos in arms sales figures to synthesize a new application of the Theory. We described the application of Chaos to decision-making, and proved arms control was a Chaotic process. From that basis, we identified the attractor and the methods to recognize stability. We concluded by developing two controls—treaties and information. Our goal was to develop an arms control policy that minimizes adverse effects. The information

uncovered in the research shows Chaos Theory helps attain our goal by identifying three causes of adverse effects:

1. Incomplete knowledge of the attractor,
2. lack of time to institute a control before a decision must be made, or
3. lack of knowledge about the controls.

What is the practical application of the Chaos in arms control? The post-cold war poses many dilemmas for arms control. The first is *the purpose of conventional arms control and the proper balance between US conventional arms control and US arms sales?* Winston Churchill once said, “It is the greatest mistake, to mix up disarmament with peace. . . . Europe will be secure when nations no longer feel themselves in great danger, as many of them do now. Then the pressure and the burden of armaments will fall away automatically.”³ Analysis of the historic record proves Churchill’s assumption and Chaos Theory re-emphasizes the point—adverse effects are not limited by arms sales. The Chaotic decision-making process does not even address “number of sales.” Chaos says the policy needs to aim at taking steps to maintain the system in the positive wing of the attractor—where the system is achieving our desired effects. This may in fact, include limiting or selling weapons, but the amount of weapons sold and to whom *as an indicator* is irrelevant.

Chaos also answered our second question: identify the role of conventional arms control negotiations and agreements.

“Success lies in how well the future state of the environment can be predicted over some number of time steps.”⁴ Arms control negotiations and treaties fulfill this role. As a control, arms control negotiations and agreements should be used to create linearity when the system shows signs of instability or Chaos when the system is becoming

detrimental to our goals. The lessons of Germany's steps to rearm are a model of manipulating the system in and out of Chaos to achieve their goal.

A third concept, not initially addressed, emerges from our application of Chaos—the use of information. Information, as a control, can help the US achieve its arms control objectives and mitigate the problems of adverse effects.

Information is used to understand and manipulate the system. The more information collected prior to a sale, the greater the decision-maker's knowledge of the attractor and its stability. If the system indicates a possible adverse effect, information can manipulate the system, causing an adverse effect for an adversary. (Refer to our historical example of Germany's rearmament or the hypothetical example of North Korea.)

Focusing on attractors and using controls can help manipulate the system to reach the desired goal. Did the Somali warlords inadvertently stumble upon the controls to cause the US to send millions of dollars into the country, and then force the military to leave? What would be the adverse effects if the US delivered military instead of humanitarian assistance?

Recommendations

The US arms sales approval process is an involved bureaucracy. Multiple people capable of effecting arms sales fractionalizes knowledge of both the attractor and stability. Realistically, arms sales as a part of US foreign and domestic policy, involves numerous organizations, including the President, his cabinet, Congress, staffers, and policy development organizations. Recommend further study on the arms sales policy

and approval process to identify the best organization and approval process to take advantage of Chaos principles.

In synthesizing our application, we uncovered many areas outside the scope of this research paper where Chaos can effect decision-making. We therefore, also recommend further study on the application of Chaos to decision-making, especially with regards to identifying multi-dimensional attractors, methods to identify system stability, and identification of control parameters.

Limitations of the Study

Our aim was an application of Chaos that was logical and consistent with the math to form a new theoretical basis. One of the limitations of the study was our level of Chaos knowledge and the lack of precedent for the work we undertook. The research, including discussions with some of the most highly regarded experts in the field, gave us a solid understanding about how Chaos effects arms control. Many of the concepts we developed, however, require rigorous proofs to establish as undisputed fact. These proofs are beyond the scope of the project.

Our research, was also aimed at bringing two audiences together: the scientists who understand the mathematical application of Chaos and the social scientists who understand decision-making. In that context, our description of Chaos tended to trade strict mathematical accuracy for increased comprehension.

Notes

¹ Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret, (Princeton, N.J.: Princeton University Press, 1976), 87.

² Gray, p 37.

Notes

³ Glynn, p 364-365.

⁴ Gottfried Mayer-Kress, "Conflict in International Systems," unpublished paper based on talk presented at SHAPE Technological Symposium on Crisis Management, Mons, Belgium, 1992, p 9.

Bibliography

- Alletoy, Sq Ldr Sam, et. al., "Planning and Execution of Conflict Termination," Research Report no. 95-05, (Maxwell AFB, Ala.: Air Command and Staff College, 1995).
- , "An ACA Panel: The Future of Arms Control," *Arms Control Today* 25, no. 1, (January/February 1995).
- Addington, Larry H., *Patterns of War Since the Eighteenth Century*, (Bloomington, Ind.: Indiana University Press, 1994).
- , "Administration Officials Testify on Arms Transfer Policy," *DISAM Newsletter* 1, no. 1, (Fall 1978).
- Al-Mashat, Abdul-Monem M. *National Security in the Third World*, (Boulder, Colo.: Westview Press, 1985).
- Amirsadegh, Hossein, ed., *The Security of the Persian Gulf*, (New York: St Martin's Press, 1981).
- Anthony, Ian, "The Global Arms Trade," *Arms Control Today*, (June 1991).
- Arms Control and Disarmament Agency and Arms Control Association, "FACTFILE, US Data for the UN Conventional Arms Register," *Arms Control Today* 25, no. 5, (June 1995).
- Arms Sales Monitor* #31, 5 Dec 1995. <http://fas.psych.nwu.edu/fas.files/asm/Dec95.html>.
- Atwood, Donald J., "Assessing the Defense Industrial Base," *DISAM Journal* 12, no. 1, (Fall 1989).
- Barnaby, Frank, *The Role And Control Of Weapons In The 1990s*, (London: Routledge Press, 1992).
- Barton, John H., "The Developing Nations and Arms Control," *Studies in Comparative International Development* 10, (Spring 1975).
- Bartholomew, Reginald, "Conventional Arms Sales Policies of the U.S., CIS, China, Britain, and France," *DISAM Journal* 14, no. 3, (Spring 1992).
- Bartholomew, Reginald, "Curbing Destabilizing Arms Transfers," *DISAM Journal* 14, no. 4, (Summer 1994).
- Buckley, Undersecretary of State for Security Assistance, Science, and Technology, James L., statement to the Senate Foreign Relations Committee, 28 July 1981, quoted in *DISAM Newsletter* 4, no.1, (Fall 1981).
- Boyd, John R., "A Discourse On Winning And Losing," (A collection of unpublished briefings and essays), August 1987.
- Carpenter, Ted Galen, "The Unintended Consequences of Afghanistan," *World Policy Journal*, (Spring 1994).
- Carter, President Jimmy, responding to a question about aircraft sales to Middle East, Spokane Town Meeting, 5 May 1978, quoted in *DISAM Newsletter* 1, no. 1, (Fall 1978).

- Carter, President Jimmy, responding to a question about aircraft sales to Middle East, Spokane Town Meeting, 5 May 1978, quoted in *DISAM Newsletter 1*, no. 1, (Fall 1978).
- Churchill, Winston S., *Memoirs of the Second World War*, (Boston: Houghton Mifflin Company, 1987).
- Clarke, Richard A. "The Changing Nature of U.S. Military Assistance," *DISAM Journal 13*, no. 1, (Fall 1990).
- Clausewitz, Carl von, *On War*, ed and trans. Michael Howard and Peter Paret, (Princeton, N.J.: Princeton University Press, 1976).
- Cohen, Eliot A. and John Gooch. *Military Misfortunes, The Anatomy of Failure in War*, (New York : Vintage Books, 1990).
- , "Commission considers preliminary elements of guidelines on arms transfers," *UN Chronicle 31*, no. 3, (September 1994),
- Congress of the United States Office of Technology Assessment, *Global Arms Trade, Commerce in Advanced Military Technology and Weapons*, (Washington, D.C.: U.S. Government Printing Office, 1989).
- Coveney, Peter and Roger Highfield, *Frontiers of Complexity, The Search for Order in a Chaotic World*, (New York: Fawcett Columbine, 1995).
- Croft, Stuart and Phil Williams, editors, *Arms Control Contemporary Security Policy*, (London: Frank Cass Press, 1986).
- Cvitanovic, Predrag, *Universality in Chaos*, (New York: Adam Hilger Press, 1989).
- Dobbs, Michael, "Saudis Funded Weapons For Bosnia, Official Says, \$300 million Program Had U.S. 'Stealth Cooperation,'" *The Washington Post*, Friday, Feb 2, 1996.
- Dublois, Maj Bruce, "Deterministic Philosophical Assumptions in the Application of Chaos Theory to Social Events," unfinished Research Report, (Maxwell AFB, Ala: School of Advanced Airpower Studies)
- Defense Institute Security Assistance Management, "New U.S. Conventional Arms Transfer Policy," *DISAM Newsletter 4*, no.1, (Fall 1981).
- Department of Defense, *World-Wide Conventional Arms Trade (1994-2000) A Forecast and Analysis, December 1994* (Washington, D.C.: Government Printing Office, 1994).
- Doughty, Robert Allan, *The Breaking Point, Sedan and the Fall of France, 1940.*, (Hamden, Conn.: Archon Books, 1990).
- Dupuy, Col T.N., *Numbers, Predictions and War: Using History to Evaluate Combat Factors and Predict the Outcome of Battles*, (Fairfax, Va.: Hero Books, 1985).
- Eisenhour, John H., "Offesets in Military Exports: U.S. Government Policy," *DISAM Journal 12*, no. 1, (Fall 1989).
- Executive Order 12946—President's Advisory Board on Arms Proliferation Policy, January 20, 1995, in *Weekly Compilation of Presidential Documents 31*, no. 4, (January 30, 1995).
- Fadok, Major David S., "John Boyd and John Warden, Air Power's Quest for Strategic Paralysis," School of Advanced Aerospace Studies, (Maxwell AFB Ala.: Air University Press, 1995).
- Famighetti, Robert, ed., *The World Almanac and Book of Facts, 1996*, (New York: Funk and Wagnells and Company, 1995).

- Feinstein, Lee, "Bush Unveils Long-Awaited Middle Eastern Arms Control Plan," *Arms Control Today*, (June 1991).
- Gleick, James, *Chaos, Making a New Science*, (New York : Penguin Books, 1987).
- Glynn, Patrick. *Closing Pandora's Box, Arms Races, Arms Control, And The History Of War*, (New York: New Republic Books, 1987).
- Grimmett, Richard F., "Conventional Arms Transfers to the Third World, 1985—1992," *DISAM Journal* 16, no. 1, (Fall 1993).
- Grimmett, Richard F., "Conventional Arms Transfers in the Post-Cold War Era," [gopher://gopher.cdi.org:70/0/atdb/patterns/analysis/93-852f.txt](http://gopher.cdi.org:70/0/atdb/patterns/analysis/93-852f.txt)
- Gilks, Anne and Gerald Segal *China and the Arms Trade*, (New York: St Martin's Press, 1985).
- Gordon, Danielle, "Cut Foreign Arms Sales," *Bulletin of Atomic Scientists* 51, no. 5, (September 1995).
- Gray, Colin S., *House of Cards, Why Arms Control Must Fail*, (Ithaca N.Y.: Cornell University Press, 1992).
- Grossman, Siegfried, and Gottfried Mayer-Kress, "Chaos in the International Arms Race," *Nature* 337, no. 23, (February, 1989).
- Grimmett, Richard F., "Conventional Arms Transfers to the Third World, 1985—1992," *DISAM Journal* 16, no. 1, (Fall 1993).
- Statement of Edward W. Gnehm, Jr., Deputy Assistant Secretary for Near Eastern and South Asian Affairs, Department of Defense, House, *Proposed Arms Sales to Kuwait*.
- Halasz, Michael F., "Nonlinear Dynamics in Behavioral Systems," *American Psychologist*, (February 1995).
- Hamilton, Lee H., "Middle Eastern Arms Restraint: An Obligation to Act," *Arms Control Today*, (June 1991).
- The International Peace Directory*, (Plymouth, United Kingdom: Northcote House Publishers, 1988).
- Hartung, William D., *And Weapons For All*, (New York: HarperCollins Publishers, 1994).
- Hartung, William D., "Nixon's Children, Bill Clinton and the Permanent Arms Bazaar," *World Policy Journal* 12, no. 2, (Summer 1995).
- House, Proposed Arms Sales to Kuwait: Hearing Before the Subcommittees on Arms Control, International Security and Science, and on Europe and the Middle East of the Committee on Foreign Affairs," 100th Cong, 2nd sess, 1988.
- Houweling, H.W. and J.B. Kune, "An Inquiry into the War Proneness of Nations, 1821—1980," *Current Research on Peace and Violence* 8, no 2 (1985).
- James, Major Glenn, *Chaos lecture* videotape, Air University TV, 1994.
- James, Major Glenn letter, subject: Chaos in Decision making, 27 March 1996.
- James, Major Glenn E., "Chaos Theory: The Essentials for Military Applications," Research Report, (Newport, R.I.: Naval War College, 1995).
- Karush, William, PhD., *Webster's New World Dictionary of Mathematics*, (New York: Simon and Schuster, Inc., 1989).
- Keeny, Spurgeon M., "Arms Sales: The New World Order?", *Arms Control Today*, (April 1991).

- Keeny, Spurgeon M., "The President's Arms Control Initiative: Talking Peace, Selling Weapons," *Arms Control Today*, (June 1991).
- Kemeny, John G. and J. Laurie Snell, *Mathematical Models in the Social Sciences*, (Boston: Ginn and Company, 1985).
- Kemp, Geoffrey, "Dilemmas of the Arms Traffic," *Foreign Affairs* 48, (January 1970).
- Khripunov, Igor, "Conventional Arms Control Initiatives: Russia as a Special Case," *Arms Control Today* 24, no. 10, (December 1994).
- Kaufman, Robert Gordon, *Arms Control During the Pre-Nuclear Era: The United States and Naval Limitation Between the Two World Wars*, (New York: Columbia University Press, 1990).
- Kirk, Elizabeth J., "Technology, Security, and Arms Control for the 1990s," *Colloquium of the American Association for the Advancement of Science*, (1988).
- Klare, Michael T., "Gaining Control: Building a Comprehensive Arms Restraint System," *Arms Control Today*, (June 1991).
- Koulik, Sergey and Richard Kokoski, *Conventional Arms Control, Perspectives on Verification*, (New York: Oxford University Press, 1994).
- Labrie, Roger P., John G. Hutchins, and Edwin W.A. Peura, *US Arms Sales Policy Background and Issues*, (Washington, D.C.: American Enterprise Institute for Policy Research, 1992).
- Leahy, Patrick, "Hidden Killers: Solving the Global Land Mine Crisis," *America* 172, no 21, (June 17, 1995).
- Louscher, David J., "The Rise Of Military Sales As a U.S. Foreign Assistance Instrument," *Orbis* 20, (Winter 1977).
- Lumpe, Lora, "Clinton's Conventional Arms Export Policy: So Little Change," *Arms Control Today* 25, no. 4, (May 1995).
- McCausland, Col Jeffery D. "The Way Ahead In Conventional Arms Control," Research Report, (Carlisle Barracks: U.S. Army War College, 1995).
<http://tesuque.cs.sandia.gov/~bbooth/docs/marshallplan.html>).
- Mayer-Kress, Gottfried, "Conflict in International Systems," unpublished paper based on talk presented at SHAPE Technological Symposium on Crisis Management, Mons, Belgium, 1992.
- Meyers, Robert A. editor, *Encyclopedia of Modern Physics*, (San Diego, Calif.: Academic Press, Inc., 1990).
- Muttam, John, *Arms and Insecurity in the Persian Gulf*, (Kalkaji, New Dehli, India: Radiant Publishers, 1984).
- Neuman, Stephanie G., "The Arms Trade, Military Assistance and Recent Wars: Change and Continuity," *Annals of the American Academy of Political and Social Science* 541, (September 1995).
- Neuman, Stephanie, "Security, Military Expenditures, and Socioeconomic Development: Reflections on Iran," *Orbis* 22, (Fall 1978).
- , "Non-Proliferation and Export Control Policy, White House Unveils New Framework," *Defense Trade News* 5, no. 1, (January 1994).
- Office of the Press Secretary, "FACT SHEET Conventional Arms Transfer Policy," The White House, 17 February 1995.

- Office of the Press Secretary, "FACT SHEET Criteria for Decisionmaking on U.S. Arms Exports," The White House, 17 February 1995.
- Opportunities for Conventional Arms Limitations in the Middle East and Persian Gulf*, <http://www.biv.ac.il/~steing/carnegie.html>.
- Pierre, Andrew J. editor, *Arms Transfers and American Foreign Policy*, (New York: New York University Press, 1979).
- Pierre, Andrew J., "Arms Sales: The New Diplomacy," *Foreign Affairs* 60, (Winter 1981/1982).
- Pierre, Andrew J., *The Global Politics of Arms Sales*, (Princeton N.J.: Princeton University Press, 1982).
- Public Law 87-297. September 26. 1961 "The Arms Control and Disarmament Act"
- Richards, Diana, "Is Strategic Decision Making Chaotic?", *Behavioral Science* 35, no. 3, (July 1990).
- Rowen, Henry S., "U.S. Military Assistance in the 90's," *DISAM Journal* 12, no. 4, (Summer 1990).
- Regehr, Ernie, "Canada Prods United States on Arms Sales," *Arms Control Today*, (June 1991).
- Saaty Thomas L., *Mathematical Models of Arms Control and Disarmament. Application of Mathematical Structures in Politics*, (New York: John Wiley and Sons, Inc., 1988).
- Samelson, Louis J., "Legislative Constraints on U.S. Arms Transfers," *DISAM Journal* 12, no. 1, (Fall 1989).
- Seligman, Daniel, "Of Laws and Butterflies," *Fortune* 131, no. 12, (June 26, 1995).
- Shotwell, Major Charles B., "US Foreign Military Sales After Europe 1992: Reconsidering Market Strategies," *DISAM Journal* 12, no.2, (Winter 1989-1990).
- SIPRI Yearbook of World Disarmament, 1968/69.*, Stockholm International Peace Research Institute, (Stockholm: Humanities Press, 1969).
- SIPRI Yearbook, 1968/69: World Armaments and Disarmament*, (New York: Humanities Press, 1969).
- SIPRI Yearbook, 1985: World Armaments and Disarmament*, (Philadelphia: Taylor and Francis Press, 1985).
- SIPRI Yearbook, 1995: Armaments, Disarmament and International Security*, (New York: Oxford University Press, 1995).
- SIPRI Yearbook, 1995: Armaments, Disarmament and International Security*, (New York: Oxford University Press, 1995).
- Small, Melvin and J. David Singer, *Resort To Arms, International And Civil Wars, 1816-1980*, (Beverly Hills, Calif: Sage Publications, 1982).
- Statement of the President, 29 November 1978, in *DISAM Newsletter* 1, no. 2, (Winter 1978-1979).
- Tagarev, Lt Col Todor, , et. al., "Chaos in War: Is It Present and What Does It Mean?", Research Report 94-301, (Maxwell AFB, Ala.: Air Command and Staff College, 1994).
- U.S. Arms Control and Disarmament Agency, "Threat Control through Arms Control," Report to Congress, 1994.

- U.S. Arms Control and Disarmament Agency, *World Military Expenditures and Arms Trade, 1963-1973*, (Washington, D.C.: U.S. Government Printing Office, 1975).
- U.S. Arms Control and Disarmament Agency, *World Military Expenditures and Arms Trade, 1993-1994*, (Washington, D.C.: U.S. Government Printing Office, 1995).
- "US Conventional Arms Transfer Policy Directive, Jul 8, 1981," quoted in *DISAM Newsletter* 4, no. 1, (Fall 1981).
- Vance, Secretary of State Cyrus, statement to the Senate Committee on Foreign Relations, 2 March 1978, quoted in *DISAM Newsletter* 1, no. 1, (Fall 1978).
- Van Evera, Shapiro & Valentino, "National Misperception and the Causes of War," <http://cis-server.mit.edu/DACS/milper.html>.
- Wagenmakers, Ambassador Hendrik, "The UN Register of Conventional Arms: The Debate on the Future Issues," *Arms Control Today* 24, no. 8, (October 1994).
- Walkling, Sarah, "CFE Parties Reach Milestone in Conventional Force Reductions," *Arms Control Today*, (January/February 1995).
- Wakling, Sarah, "FACTFILE, 1993 UN Conventional Arms Register," *Arms Control Today*, (January/February 1995).
- Walkling, Sarah, "U.S. Remains No.1 Arms Exporter As Demand for U.S. Weapons Falls," *Arms Control Today* 25, no. 6, (July 1995).
- Wakling, Sarah, *Arms Control Today* 25, no. 2, (March 1995).
- Weiner, Tim, "U.S. Will Try to Buy Antiaircraft Missiles Back from Afghans," *The New York Times*, Thursday, July 24, 1993.
- Washington Institute's Strategic Study Group, *Restoring the Balance, US Strategy and the Gulf Crisis*, Initial Report of the Washington Institute's Strategic Study Group. (Washington, D.C.: Washington Institute for Near East Policy, 1991).
- Wilkinson, David, *Deadly Quarrels, Lewis F. Richardson and the Statistical Study of War*, (Berkeley, Calif., University of California Press, 1980).
- Wisner, Frank G., "Towards a New Conventional Arms Transfer Policy," *DISAM Journal* 16, no. 3, (Spring 1994).